MOBIUS INSTITUTE

VIBRATION TRAINING ACTIVITY BOOK

CATEGORY II

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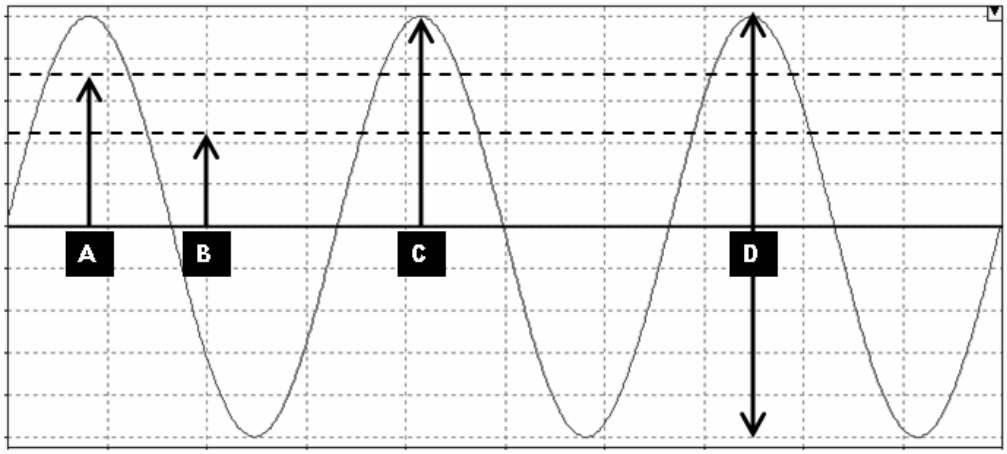
VIBRATION FUNDAMENTALS

[1] Circle the **RMS level** on this chart.

[2] True or False: The peak-level is always twice the peak level.

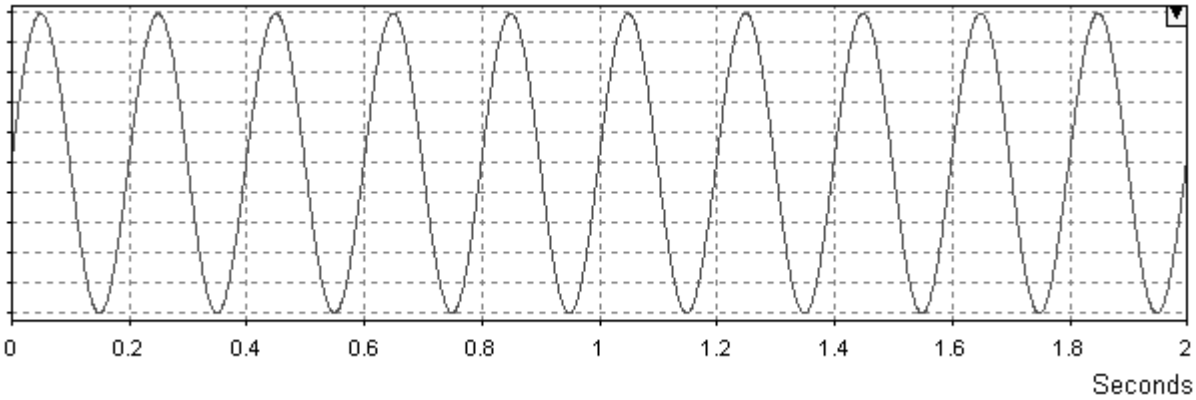


A. True
B. False

[3] Write down the relationship between frequency and period:

A. They are the same
B. Frequency (Hz) = 1/Period (seconds)
C. Frequency = Period^2
D. Frequency (CPM) = 1/Period (seconds)

[4] What is the frequency of the sine wave below?



A. 10 Hz B. 5 Hz C. 0.2 Hz D. 2 Hz

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VIBRATION FUNDAMENTALS: AVD

[1] The measurement that relates to the position of the shaft in the journal/sleeve bearing is...

A. Displacement
B. Velocity
C. Acceleration

[2] What is a “proximity probe” used to measure?

A. Displacement
B. Velocity
C. Acceleration

[3] The measurement that relates to the rate of change of the vertical movement of the shaft in the bearing is...

A. Displacement
B. Velocity
C. Acceleration

[4] The measurement that is proportional to the *stress* of the shaft on the bearing is...

A. Displacement
B. Velocity
C. Acceleration

[5] The measurement that is proportional to the *force* of the shaft on the bearing is...

A. Displacement
B. Velocity
C. Acceleration

[6] Which two vibration measures are 180 degrees out of phase?

A. Displacement and Acceleration
B. Velocity and Acceleration
C. Displacement and Velocity
D. All of the above

[7] A spectrum has a peak at 100 Hz of 5 mm/sec rms. Calculate the corresponding vibration levels in the units listed below:

in/sec pk_____

G’s rms_____

Microns (um) pk-pk _____

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[8] It is understood that vibration severity is proportional to the velocity value. Which of the following vibration levels is the most severe? (They were all recorded at the running-speed peak of a 1485 RPM motor.)

A. 10 mm/sec rms
B. 0.51 in/sec pk
C. 120 um pk-pk
D. 0.12 g's rms

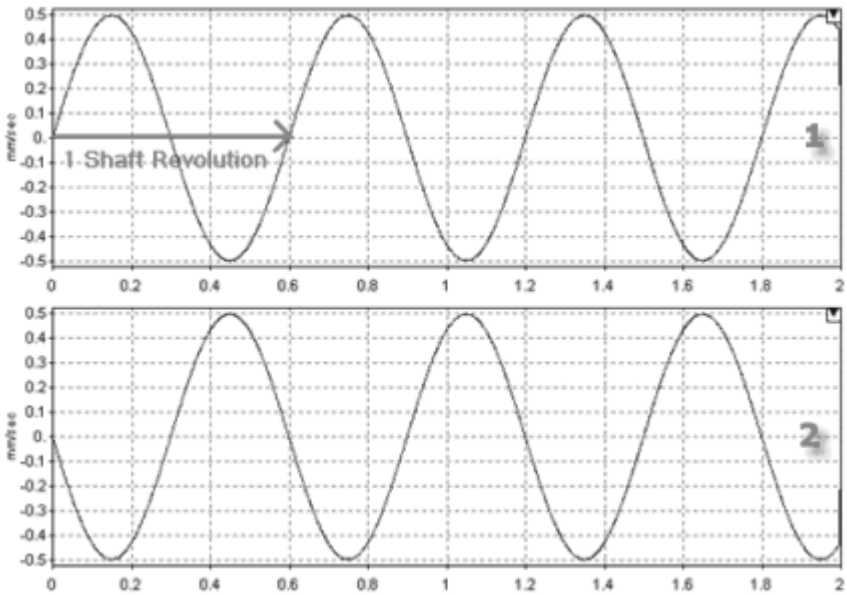
VIBRATION FUNDAMENTALS: PHASE

[1] Phase is measured in units of...

A. seconds
B. RPM
C. degrees

[2] What is the phase relationship between the following two signals?

A. In phase
B. 180 degrees out of phase
C. 90 degrees out of phase



[3] If two signals are in-phase...

A. they reach their

r maximums (peaks) at the same time B. one will reach its peak when the other is zero

C. one will reach its minimum when the other reaches its maximum

[4] If two signals are 180 degrees out-of-phase...

A. they reach their maximums (peaks) at the same time B. one will reach its peak when the other is zero

C. one will reach its minimum when the other reaches its maximum

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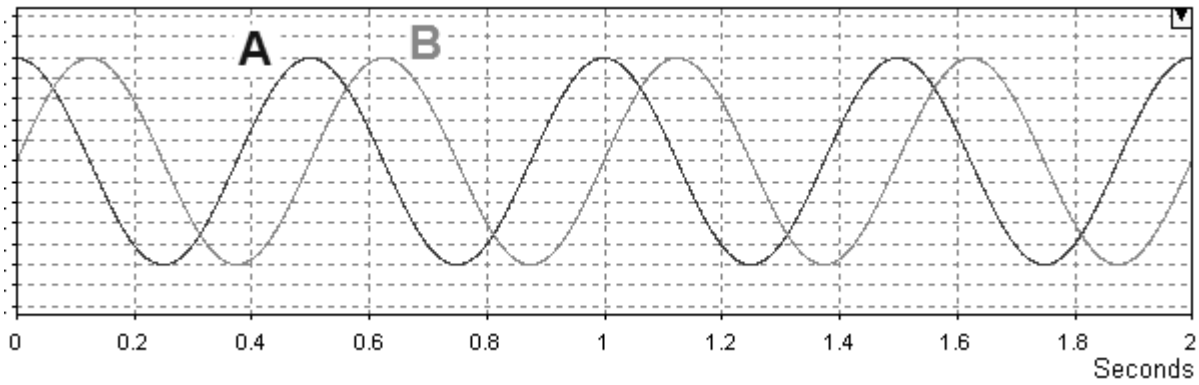
[5] If signal 1 leads signal 2…

A. signal 1 is higher in amplitude than signal 2 B. signal 1 finishes before signal 2

C. signal 1 reaches its peak BEFORE signal 2 reaches its peak D. signal 1 reaches its peak AFTER signal 2 reaches its peak

[6] Does signal **A** lead or lag signal B?



A.
Lead B.
Lag

VIBRATION FUNDAMENTALS: OVERALL READINGS

[1] Overall RMS levels are often collected and trended or compared to an alarm chart in a vibration monitoring program. Please describe the pros and cons of using this measurement.

_____

_____

[2] Please name at least two ways to calculate the RMS Overall level

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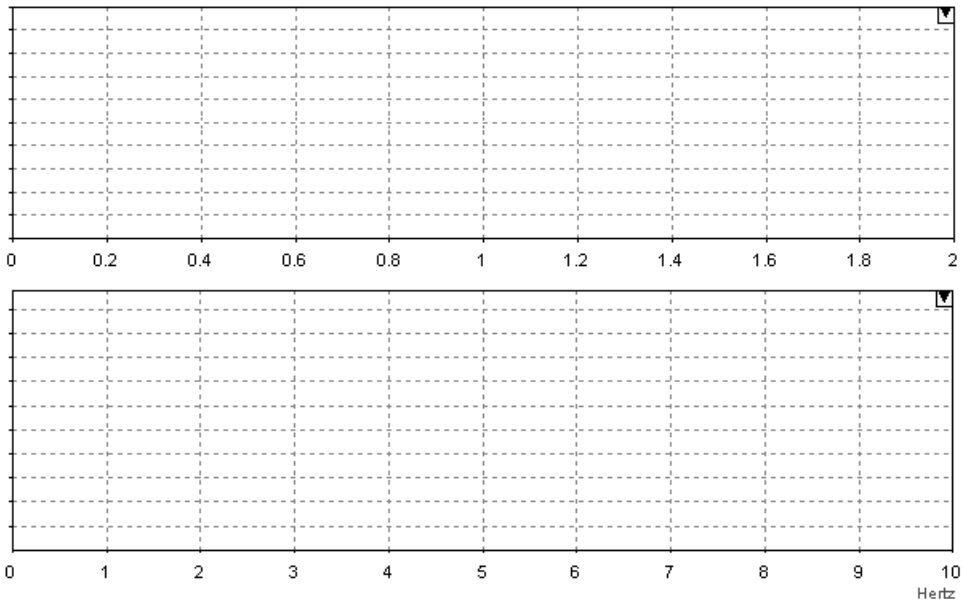
VIBRATION FUNDAMENTALS: SPECTRA

[1] If the running speed of a machine is 600 CPM, and there is peak at “8X”, calculate the frequency of that peak: _____ CPM _____ Hz _____ X

[2] If the 10X peak is at 2500 CPM, the running speed of the machine is _____ CPM

A. 250 CPM B. 2500 CPM C. 4.2 CPM

[3] **Sketch**: Draw a 2 Hz sine wave with amplitude of 1 mm/sec. Draw the corresponding spectrum on the chart below in mm/sec rms. Annotate the y-axis (show the min and max value on the graph scale.)

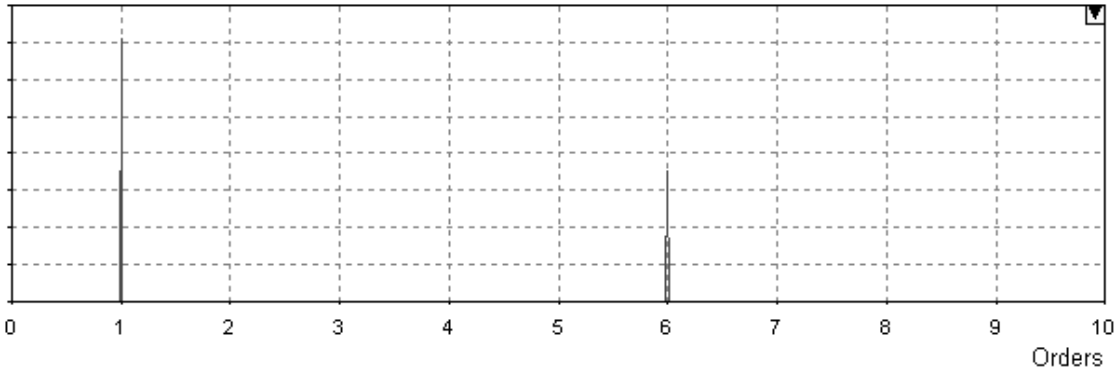


[4] What is the amplitude of the peak in the spectrum you have sketched (state the units)?

_____
_____
_____
_____
_____
____

[5] The following “order

normalized” spectrum came from a motor driving a pump at 1485 RPM via a flexible coupling. Calculate the frequency of the peak at 6X: _____ CPM



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VIBRATION FORCING FREQUENCIES

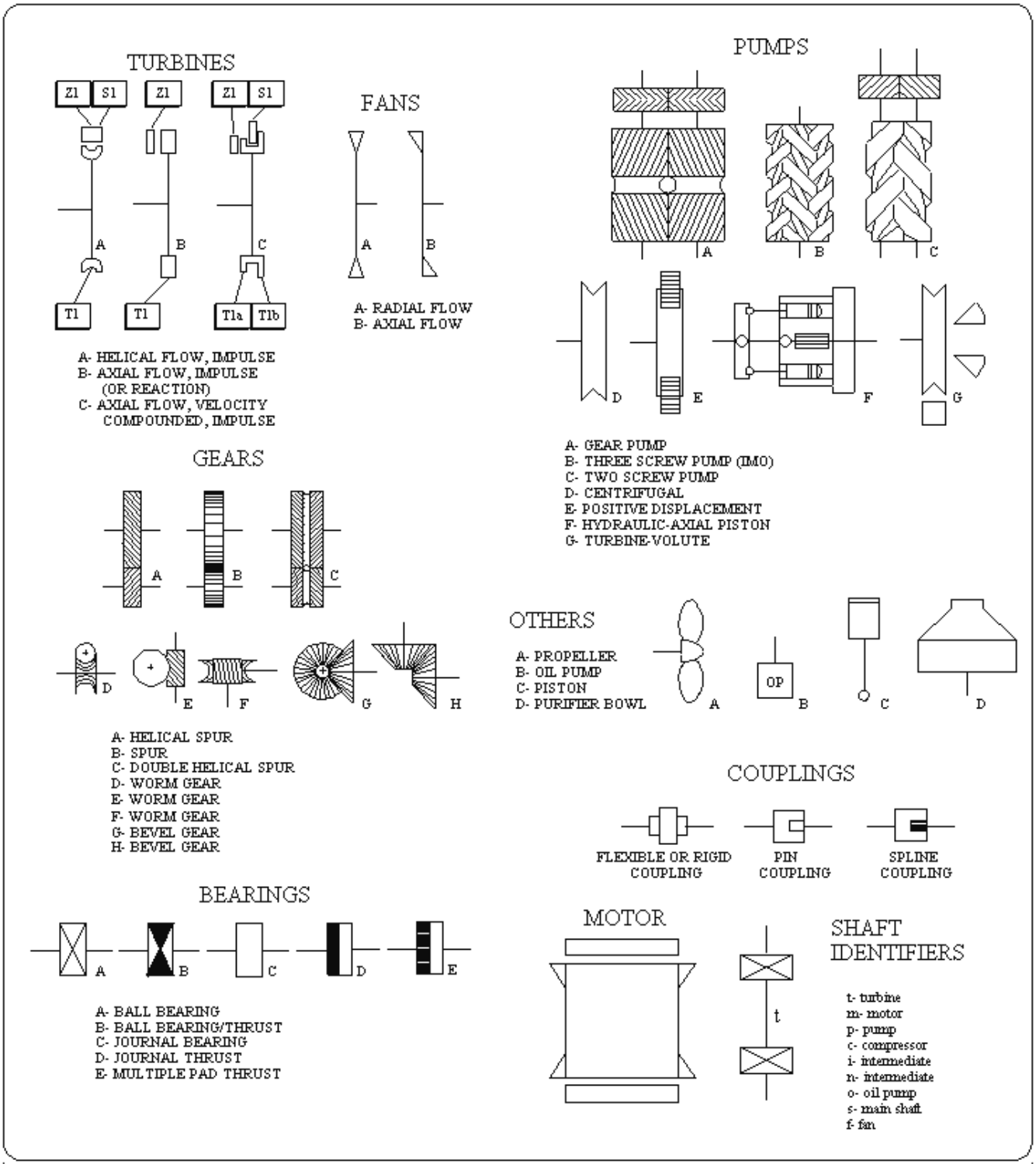

Chart courtesy DLI Engineering (ABB)

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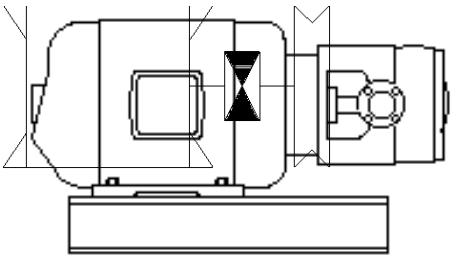
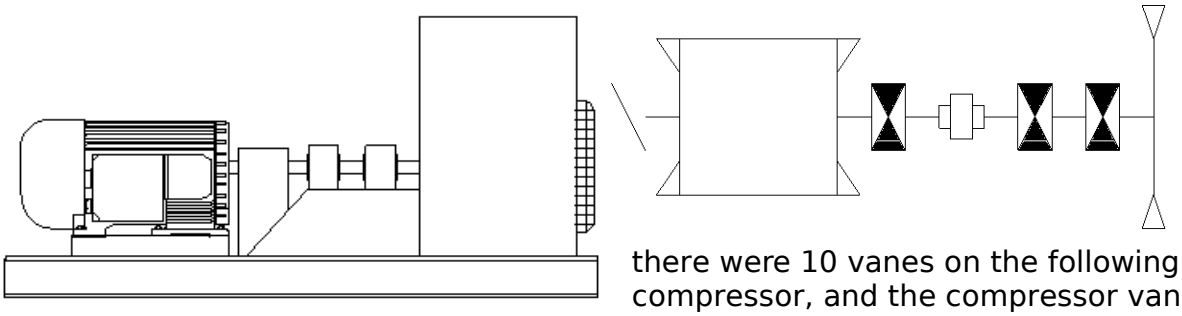
[1] If the following compressor ran at 1485 CPM, and there are 12 vanes on the impeller, calculate the compressor vane-pass rate: _____ CPM _____ Hz _____ X

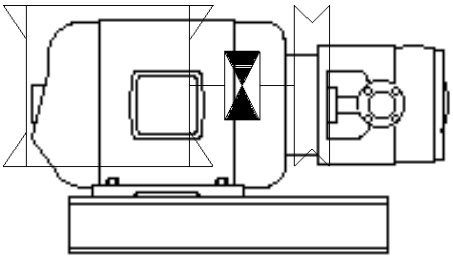
[2] If the following fan had 10 blades, and the motor RPM was 1485, calculate the blade-pass forcing frequency _____ CPM _____ Hz _____ X



[3] If there were 10 vanes on the following compressor, and the compressor vane rate was 29,700 CPM, calculate the RPM of the compressor _____ CPM



[4] If the pulley on this motor had a 100 mm diameter, and the pulley on the pump had a 350 mm diameter, and the motor speed was 2970 RPM, calculate the speed of the pump: _____ CPM



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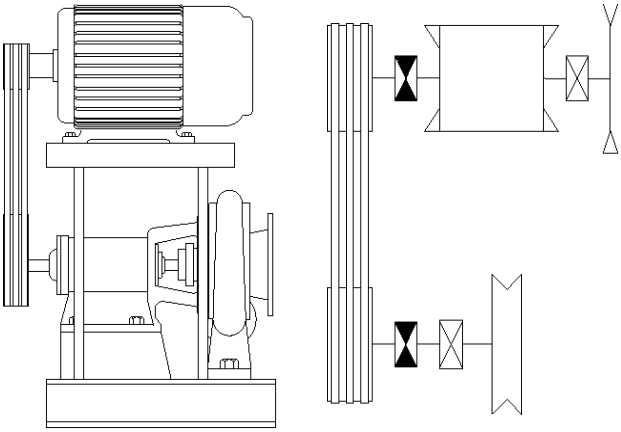

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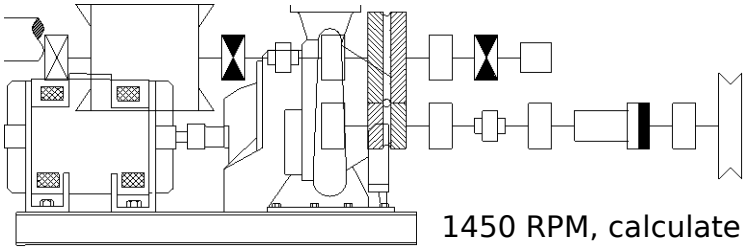
[5] If the motor speed was 1480 RPM, and the input gear of the gearbox had 39 teeth, and the pinion had 15 teeth, and the compressor had 12 vanes, provide the following details:

Gearmesh frequency: _____ X _____ CPM _____ Hz Compressor speed: _____ X _____ CPM _____ Hz Compressor vane pass rate: _____ X _____ CPM _____ Hz



[6] The two-stage gearbox below has the number of teeth on each gear and pinion as shown. From this information, and the fact that the motor speed is 1450 RPM, calculate the following information:

Stage one gearmesh frequency: _____ CPM

Speed of intermediate shaft: _____ CPM

Stage two gearmesh frequency: _____ CPM

Speed of output shaft: _____ CPM

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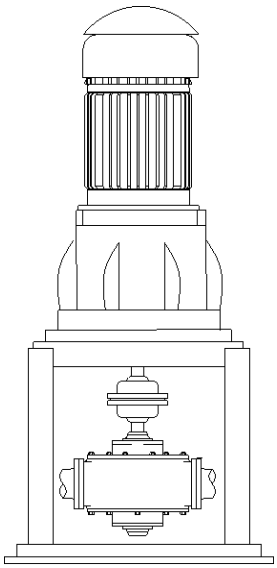

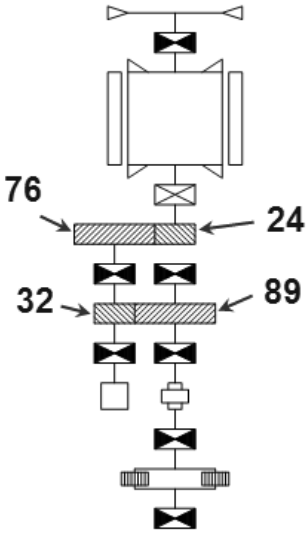

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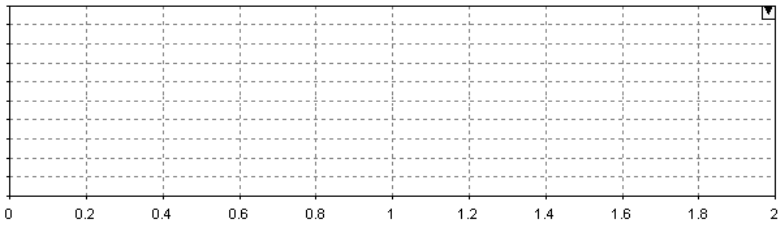
UNDERSTANDING SIGNALS

[1] **Sketch**: Imagine a machine that generates a **2 Hz** signal of **2 mm/sec** and a second **2 Hz** signal of **1 mm/sec**. There is **0 degrees** phase angle between the two signals.

Draw the resultant time waveform and spectrum in mm/sec rms. Annotate the y-axis (show the min and max value on the graph scale.)

[2] **Question**: What is the amplitude of the peak in the spectrum you have sketched (state the units)?

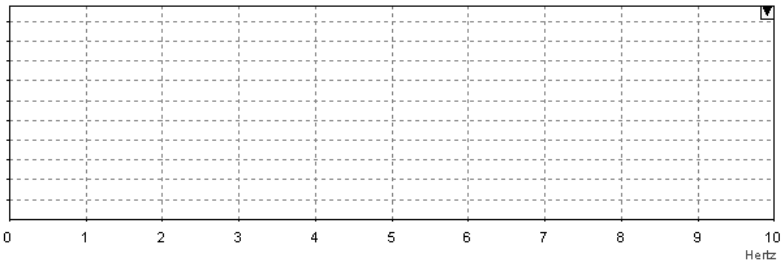


_____ _____

_____ _____

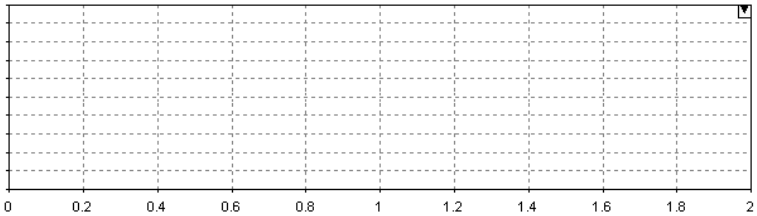
_____ _____

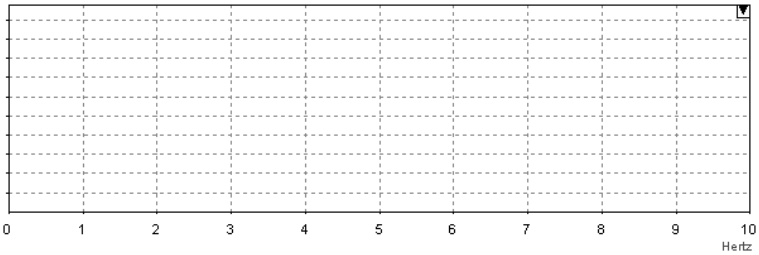
_____ _____



[3] **Sketch**: Now imagine that the two signals were 180 degrees out of phase with each other. Draw the resultant time waveform and spectrum in mm/sec rms. Annotate the y-axis (show the min and max value on the graph scale.)

[4] **Question**: What is the amplitude of the spectrum you have sketched (state the units)?





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[5] A clipped or ‘distorted’ signal will produce...

A. Half-order harmonics.
B. A series of harmonics: 1X, 2X, 3X, 4X, etc. C. Odd harmonics.
D. Even harmonics.

[6] Sub-harmonics can best be described as...

A. Same as normal harmonics, but half the size.
B. A series of evenly spaced peaks in the spectrum, starting at 0 CPM. C. A series of fractional harmonics, for example ½X, ¼X.

[7] Amplitude Modulation can best be described as...

A. The periodic change in the frequency of a signal.
B. The sound a radio makes when it is not correctly tuned. C. The periodic change in the amplitude of a signal
D. Harmonics that don't look quite right.

[8] If a signal of 200 Hz was varying in amplitude at a rate of 20 Hz, what pattern would you see in the spectrum?

A. A peak at 200 Hz, 400 Hz, 600 Hz, etc. B. A peak at 200 Hz and 20 Hz.
C. Peaks at 180 Hz, 200 Hz and 220 Hz.

[9] Two signals very close to each other in frequency will cause

A. Subtraction
B. Harmonics C. Beating
D. Amplitude modulation

[10] Describe what you would hear if an electric motor generated signals at 99 Hz and 100 Hz

A. Your last sound B. Nothing
C. A throbbing sound with a period of 1 second D. Amplitude modulation

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SIGNAL PROCESSING

Useful information:

T = Time required to collect the waveform

T_S = Time between each sample

F_S = Sampling rate = Samples per second

N = Number of samples (1024, 2048, 4096, etc.)

Window factor = 1 (no window/uniform/rectangular) or 1.5 (Hanning window)

Separating frequency ≥ 2 x Bandwidth ≥ 2 x Resolution * Window Factor

Required spectral lines ≥ 2 x Window factor x Fmax / Separating frequency

Accuracy of frequency (at peak) = ± ½ x Resolution

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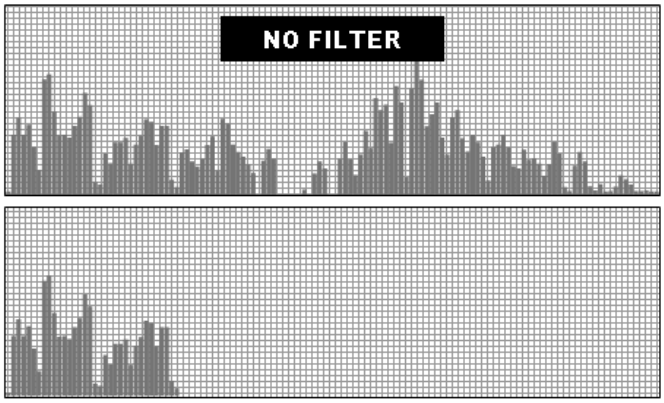
[1] If the first graph is the spectrum of the raw, unfiltered signal coming from the transducer, and that signal was put through a filter such that the spectrum in the lower graph was the result, what sort of filter must have been used?



A. High pass B. Low pass C. Band pass D. Notch (band stop)

[2] If a cyclical signal, which reaches its peak every second, was sampled every second, what would the waveform look like?

A. A straight/flat line
B. It would be a sine wave, with a frequency of 1 Hz
C. Triangular, as it went from the top of one cycle to the bottom of the next

[3] What is the Nyquist Criterion?

A. The rule that states that there must be a sufficiently high Fmax in order view closely spaced frequencies
B. The sampling rate must be greater than two times the highest frequency of interest C. The sampling rate must be 2.56 times the highest frequency

[4] For the same Fmax, if you increase the number of lines of resolution...

A. The measurement will take longer to acquire B. The test time will not change
C. The measurement will take less time to acquire

[5] Why shouldn't you always collect the highest resolution measurement possible?

A. The test takes longer
B. The data takes more room in the database
C. The data takes longer to unload from the data collector D. All of the above

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[6] If a spectrum had 1600 lines of resolution, how many samples were in the time record?

A. 1024
samples B.
2048 samples
C. 4096
samples

[7] If the record length is 10 seconds, and there were 1024 samples, what is the Fmax?

A. 40 Hz
B. 40
CPM C.
400 Hz
D. 4000 Hz

[8] If the Fmax is 10,000 Hz and you have a 1600 line spectrum, how long does it take to sample the vibration signal if you have one average only?

A. Not enough
information B. 6.25
seconds
C. 1.6
seconds D.
0.16 seconds

[9] If the Fmax is 120 Hz and you have a 3200 line spectrum, how long does it take to sample the vibration signal if you have 10 averages (no overlap)?

A. 267
seconds B.
27 seconds
C. 12
seconds D.
6 seconds

[10] What Fmax and Lines of resolution settings are required to separate vibration signals of 100 Hz and 100.50 Hz? (assume that a Hanning window will be used):

_____

[11] If a spectrum had a peak at 250 Hz, and the spectrum had 800 lines and Fmax = 800 Hz, and the window was turned off, which of the following is true about the actual source of vibration?

A. 250 ±0.5
Hz B. 250
±1 Hz C.
250 ±1.5 Hz
D. 250 ±2
Hz

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WINDOWING

[1] We experience leakage because:

A. The signal does not begin and end at zero in the time record – it is “finite”. B. There are errors in the FFT calculation.
C. Time waveforms can often have a lot of noise.

[2] The window most commonly used when route testing rotating equipment is:

A. Hanning
B. Flat top
C. Exponential
D. Uniform/Rectangular/No window

[3] The window most commonly used for bump tests is:

A. Hanning
B. Flat top
C. Exponential
D. Uniform/Rectangular/No window

[4] The window that gives greatest amplitude accuracy is:

A. Hanning
B. Flat top
C. Exponential
D. Uniform

[5] The primary reason for windowing the time waveform is:

A. To increase frequency accuracy. B. To improve amplitude accuracy.
C. To correct the leakage phenomenon.

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AVERAGING

[1] How many averages should one normally use when using linear averaging with an Fmax of 10,000 Hz?

A. 2 averages
B. 5-10
averages C.
50 averages

[2] The most commonly used averaging method used for routine data collection is:

A. Time synchronous
averaging B. Linear
averaging
C. Peak-hold averaging

[3] True or False: Linear averaging works by averaging the time waveform.

A.
True B.
False

[4] True or False: Linear averaging removes noise from the spectrum

A.
True B.
False

[5] When performing a bump test, which averaging method should be used?

A. Time synchronous
averaging B. Linear
averaging
C. Peak-hold
averaging D. Free
run averaging

[6] How many averages should normally be used when using time synchronous averaging?

A. 4-6
averages B.
10 averages
C. 20
averages
D. 100 averages (or more)

[7] True or False: Time synchronous averaging removes noise from the waveform

A.
True B.

False

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DATA COLLECTION: TRANSDUCER SELECTION

[1] In a condition monitoring program, which of these is the most important?

A. The size of your sensor. B. Test repeatability.
C. The speed of the measurement.
D. The accuracy of your measurement.

[2] True or False: I can use the same sensor for all of my vibration tests.

A. True B. False

[3] To convert from acceleration to velocity one must...

A. Integrate the signal
B. Differentiate the signal
C. Multiply by the square root of 2

[4] True or False: Integration causes a change in phase of the measurement.

A. False B. True

[5] When a signal is integrated (accel-vel) what happens to low frequency (<160 Hz) signals?

A. They are increased in amplitude B. They are reduced in amplitude C. The amplitude is not affected

[6] When integrating from acceleration to velocity, why is a high pass filter?

A. To filter out noise in the signal which is caused by machine 'rumble' B. To filter out electrical noise
C. To filter out the low frequency signals that are amplified during the integration process

[7] What type of sensor measures the relative movement between the shaft and bearing?

A. Displacement non-contact eddy current probe B. Velocity sensor
C. Accelerometer

[8] What is the difference between a charge-mode accelerometer and 'ICP' accelerometers?

A. Charge mode accelerometers require an external amplifier
B. The frequency response of an ICP accelerometer is far greater
C. ICP accelerometers are better suited to high-temperature applications

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[9] What is a piezovelocity sensor and why might someone choose to use one instead of an accelerometer?

_____

_____

[10] Which transducer is best suited to a machine tool application with **very** low vibration?

A. 10 mV/g
B. 100 mV/g
C. 1000 mV/g

[11] What would happen if you used a 10 mV/g sensor on the quiet machine tool?

A. The machine tool would appear to vibrate much more than it actually did
B. The voltage output would be small, and the amplitude resolution of data would be unacceptable
C. The sensor would 'saturate' and the vibration data would be poor

[12] What would happen if you used a 1000 mV/g accelerometer on a noisy rock crusher?

A. Sparks would fly from the transducer leads
B. The data collector would overload and may be damaged
C. The sensor would 'saturate' and the vibration data would be poor

[13] True or False: The frequency response is the same regardless of the sensitivity.

A. True
B. False

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DATA COLLECTION: SENSOR LOCATION & MOUNTING

[1] What is the **most** important factor in selecting the location for the sensor?

A. Good, clean contact with the machine
B. Located on a bearing house with a good mechanical transmission path C. Good, safe access to the mounting location
D. All of the above

[2] What is the mechanical transmission path?

A. The path you take around the machines to perform the data collection route B. The path the vibration takes between the source of vibration and the sensor
C. The vibration measured when testing gearboxes, fluid couplings and other transmission components

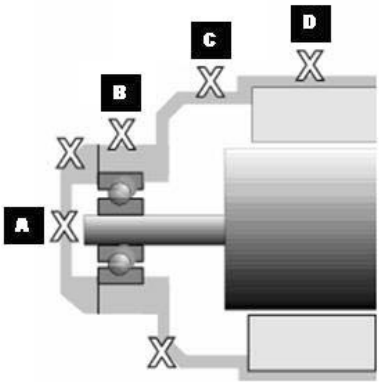
[3] If you cannot access a suitable test location for the sensor you should...

A. find another machine to monitor - that one is too hard.
B. buy a longer 'stinger' so that you can reach in to the best location.
C. mount the sensor anywhere that it vibrates - it is better than nothing. D. permanently mount a sensor, and connect it to a junction box.

[4] Circle the best transducer mounting point from the available options: **A B C D**

[5] What is repeatability?

A. The ability to perform the route in the same time every time
B. The ability to perform a test in exactly the same way every time C. The ability to perform very accurate



measurements

D. All of the above

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[6] Which is the best method of mounting a sensor (the best frequency response)?

A. Stinger, or probe tip B. Flat magnetic mount
C. Two-pole magnetic mount D. Stud mount

[7] What are the benefits of mounting (or target) pads?

A. They show exactly where the sensor should be mounted B. They provide a flat surface for the sensor
C. They are easy to clean (to remove debris) D. All of the above

DATA COLLECTION: RECOGNIZING BAD DATA

[1] Describe the 'ski-slope' phenomenon: what does it look like, why does it occur (make at least three suggestions), and what should you do if you see it during data collection?

_____

_____

_____

_____

_____

_____

_____

_____

[2] When considering the vibration sensor, what is the settling time?

A. A setting on my data collector I have never understood
B. The time it takes the sensor to convert the entire vibration pattern. C. The time it takes for the transducer to generate a stable output.

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DATA COLLECTION: PHASE

[1] What should you do if you are comparing two phase measurements in the axial direction of the machine?

_____

_____

[2] Name three methods used to collect phase readings:

_____

_____

_____

[3] Absolute phase is...

A. the phase difference between a point and an arbitrary reference B. the phase difference between two points on the machine

[4] What type of phase measurement is used when balancing?

A. Absolute phase B. Relative phase

[5] What type of phase measurement is often more convenient when measuring phase to diagnose typical machine faults?

A. Absolute phase B. Relative phase

[6] True or False: A strobe should be used as a phase reference when balancing.

A. True B. False

DIAGNOSING MACHINE FAULTS

[1] A 'synchronous frequency' is...

A. an odd multiple of the running speed frequency. B. less than the running speed frequency.
C. an integer multiple of the running speed.
D. a non-integer multiple of the running speed.

[2] A 'sub-synchronous frequency' is...

A. an odd multiple of the running speed frequency. B. less than the running speed frequency.
C. an integer multiple of the running speed.
D. a non-integer multiple of the running speed.

[3] A 'non-synchronous frequency' is...

A. an odd multiple of the running speed frequency. B. less than the running speed frequency.
C. an integer multiple of the running speed.
D. a non-integer multiple of the running speed.

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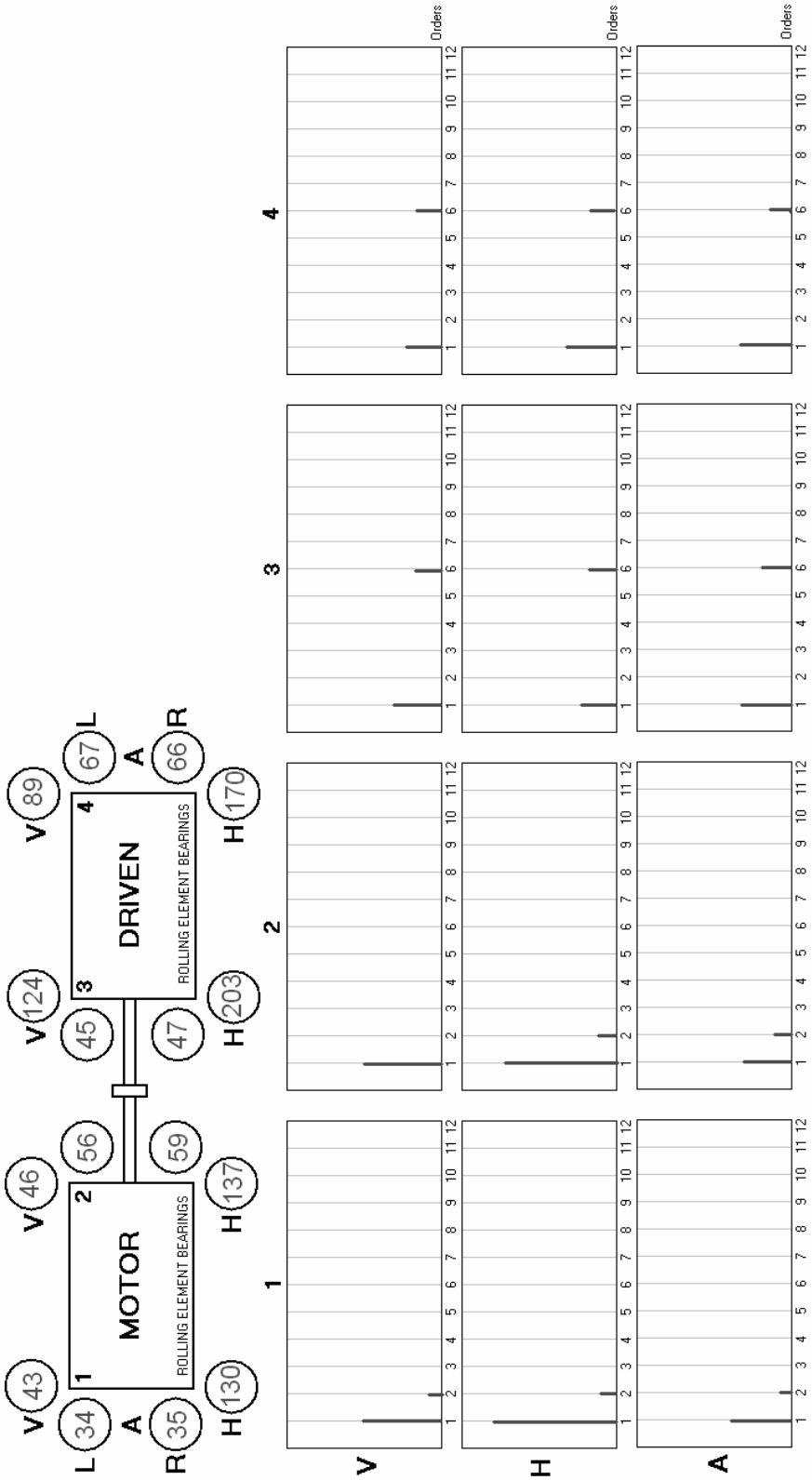
[4] What is wrong with this machine? Please briefly explain why you have come to this conclusion.

_____

_____


MOTOR
ROLLING ELEMENT BEARINGS
DRIVEN
ROLLING ELEMENT BEARINGS
1
2
3
4
V 43
V 46
V 124
V 89
L 34
A
R 35
H 130
56
59
H 137
45
47
H 203
67 L
A
66 R
H 170
V
H
A
Orders

[5] What is wrong with this machine? Please briefly explain why you have come to this conclusion.

_____

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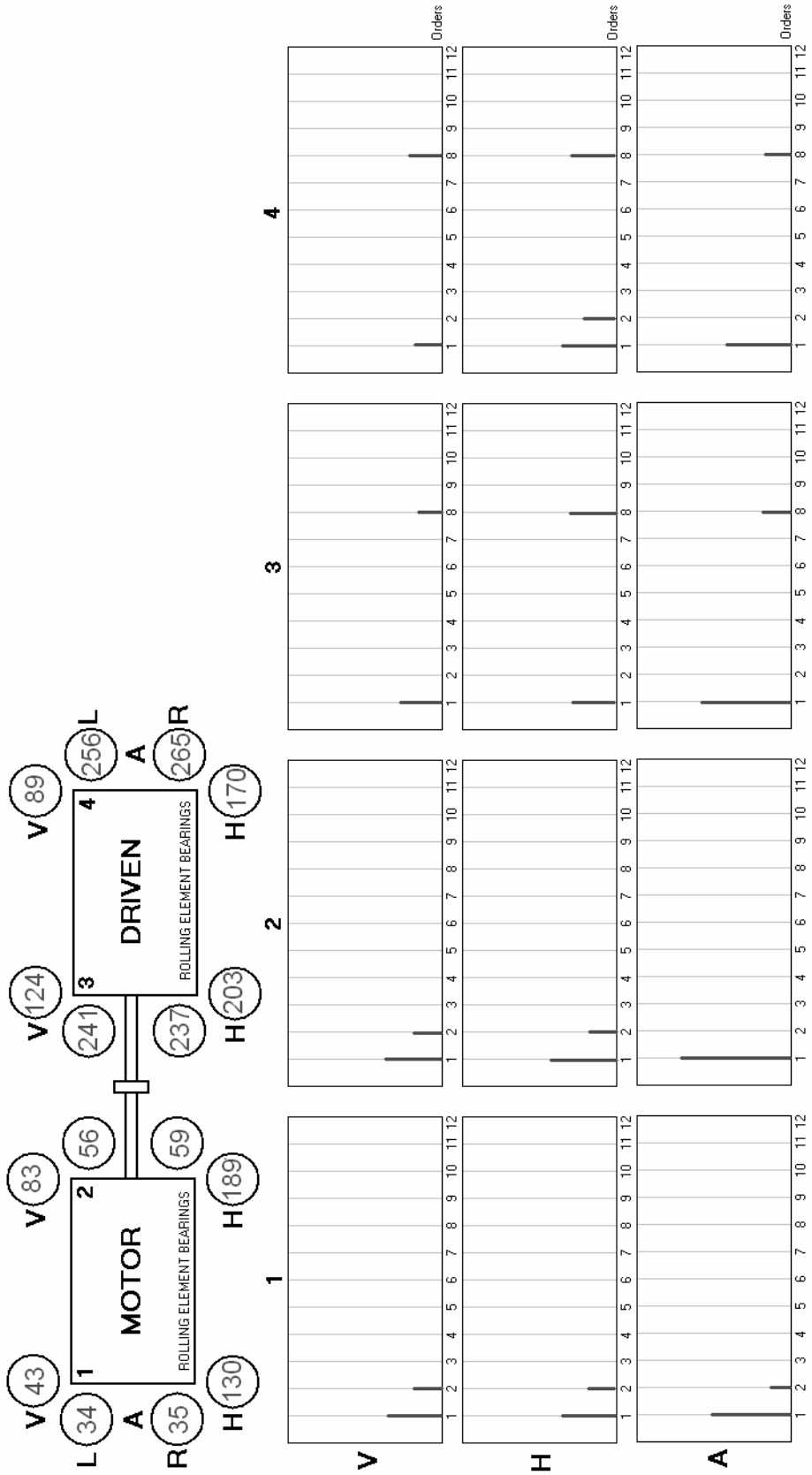

DIAGNOSING IMBALANCE

[1] If a machine (not overhung) is out of balance, the spectrum will have...

A. peaks at 1X, 2X, and 3X.
B. a high peak at 1X in the axial direction.
C. a high peak at 1X in the vertical and horizontal direction. D. a high peak at 2X.

[2] If an overhung machine is out of balance, the spectrum will have...

A. peaks at 1X, 2X, and 3X.
B. a high peak at 1X in the axial direction.
C. a high peak at 1X in the vertical, horizontal and axial directions. D. a high peak at 2X.

[3] If a vertical machine is out of balance, the spectrum will have...

A. peaks at 1X, 2X, and 3X.
B. a high peak at 1X in the axial direction.
C. a high peak at 1X in the radial (horizontal) directions. D. a high peak at 2X.

[4] The amplitude of the 1X peak due to imbalance is proportional to...

A. the amount of lubricant in the bearings. B. the load on the machine.
C. the speed of the machine.
D. the square of the speed of the machine.

[5] If a machine is out of balance, the velocity waveform will...

A. not contain any useful information. B. have numerous pulses.
C. look quite flat.
D. be mostly sinusoidal (look somewhat like a sine wave).

[6] With static imbalance...

A. the two ends of the machine in the vertical direction will be in phase.
B. the two ends of the machine in the vertical direction will be out of phase.

[7] With couple imbalance...

A. the two ends of the machine in the vertical direction will be in phase.
B. the two ends of the machine in the vertical direction will be 180 deg out of phase.

[8] Select a common cause of imbalance.

A. Uneven dirt build-up, corrosion or erosion B. Machining errors.
C. Missing balance weights. D. All statements are true.

[9] If I have a **large 24 Hz (1440 RPM)** motor-pump with a peak at running speed of **3.0 mm/sec rms** (and the fault was suspected to be imbalance), according to the chart below, what is the severity of this condition?

Key for vibration limits:

Limits are for "normal" machines operating from 1500 RPM to 3600 RPM

- Reduce limits by 4 dB (multiply limits by 0.63) for slower machines
- Increase limits by 4 dB (multiply limits by 1.6) for large and/or higher speed machines • Increase limits by 8 dB (multiply limits by 2.5) for reciprocating machines.

1X Vibration Level			**Diagnosis**	**Repair Priority**
in/sec pk	**mm/s rms**	**VdB (US)**		
<0.134	<2.5	<108	Slight Imbalance	No Recommendation
0.134-0.28	2.5-5.0	108 – 114	Moderate Imbalance	Desirable
0.28 – 0.88	5 – 15.8	114 – 124	Serious Imbalance	Important
>0.88	>15.8	>124	Extreme Imbalance	Mandatory

DIAGNOSING ECCENTRICITY

[1] If a sheave/pulley or rotor is eccentric, the spectrum will have...

A. peaks at 1X, 2X, and 3X.
B. a high peak at 1X in the axial direction. C. a high peak at 1X in the radial directions. D. a high peak at 2X.

DIAGNOSING MISALIGNMENT

[1] If a machine has angular misalignment, in the axial direction the spectrum will have...

A. peaks at 1X, 2X, 3X, 4X, etc. B. a high amplitude peak at 1X.
C. high amplitude peaks at 1X and 2X. D. a high peak at 2X only.

[2] Describe the phase relationship across the coupling when angular misalignment exists.

A. In-phase in the radial direction, and out-of-phase in the axial direction. B. Out-of-phase in the radial and axial directions.
C. In-phase in the axial direction and out-of-phase in the radial directions. D. In-phase in the radial and axial directions.

[3] If a machine has parallel misalignment, in the radial directions the spectrum will have...

A. peaks at 1X, 2X, 3X, 4X, etc.
B. a moderate-high amplitude peak at 1X and a high 2X peak. C. moderate amplitude peaks at 1X and 2X.
D. a high peak at 2X only.

[4] Describe the phase relationship across the coupling when parallel misalignment exists.

A. In-phase in the radial direction, and out-of-phase in the axial direction. B. Out-of-phase in the radial and axial directions.
C. In-phase in the axial direction and out-of-phase in the radial directions. D. In-phase in the radial and axial directions.

[5] Select a common cause of misalignment.

A. Inaccurate assembly of components.
B. Relative position of components changing after assembly. C. Distortion due to forces exerted by piping.
D. All of the above.

[6] It is important to correct a misalignment conditions because...

A. the high vibration level can create resonant

conditions. B. you will void the coupling warranty.

C. misaligned machines can create pipe-strain.

D. high vibration level (increases stresses) can damage bearings and cause premature failure.

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[7] Why are imbalance faults on overhung machines sometime misdiagnosed as misalignment faults?

A. Because it is hard to correctly align overhung machines.
B. Because both conditions result in 1X vibration in the axial direction. C. Because both conditions result in 2X vibration in the axial direction. D. Gee, I don't know!

DIAGNOSING BENT SHAFT

[1] Why might a bent shaft be misdiagnosed as an angular misalignment fault?

A. Because bent shafts cause the coupling to be misaligned.
B. Because both conditions result in 1X vibration in the axial direction. C. Because both conditions result in 2X vibration in the axial direction.

[2] If a shaft is bent, what will be the phase relationship when measured at either end of the machine?

A. In-phase in the vertical direction, but out-of-phase in the horizontal direction. B. In-phase when measured axially.
C. Out-of-phase when measured axially.
D. Phase is not a useful tool for diagnosing a bent shaft.

DIAGNOSING LOOSENESS

[1] Name one of the causes of *rotating* looseness.

A. Motor not bolted down securely.
B. Loose cowling or other metallic structure. C. Wear within a rolling element bearing.
D. Pedestal bearing not bolted down sufficiently.

[2] If you witnessed a series of 1X harmonics, which would you suspect?

A. Rotating looseness.
B. Structural looseness (foundation flexibility). C. Pedestal bearing looseness.
D. All of the above

[3] If you witnessed a 1X peak in the vertical direction, and a *much* stronger 1X peak in the horizontal direction, which would you suspect?

A. Rotating looseness.
B. Non-rotating looseness.
C. Structural looseness (foundation flexibility). D. Pedestal bearing looseness.

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[4] If you witnessed a 1X, 2X, and 3X peak, which would you suspect?

A. Rotating looseness.
B. Non-rotating looseness.
C. Structural looseness (foundation flexibility). D. Pedestal bearing looseness.

[5] Can phase be used to detect rotating looseness?

A. Yes, there is a 180 degree phase difference between vertical and horizontal. B. No, phase does not tell you anything.
C. Yes, the lack of a phase relationship helps you to distinguish looseness from misalignment and other fault conditions.

DIAGNOSING RESONANCE

[1] What is the difference between a natural frequency and resonance?

_____

_____

[2] If the running speed of the machine was changed so that it now coincided with a natural frequency, how would the vibration amplitude change?

A. It will remain unchanged
B. It will increase if the machine was out-of-balance and the machine speed was decreased. C. It will decrease in amplitude due to resonance
D. It will increase in amplitude due to resonance

[3] A bump test is...

A. a way to seek revenge on annoying machines. B. a way to identify the natural frequencies.
C. a way to tell if your colleague is awake.
D. a way to change the dynamics of the machine.

DIAGNOSING BEARING FAULTS

[1] What percentage of bearings reach their design lifetime?

A. Approximately 10% B. Approximately 50%
C. Approximately 90%

[2] Order normalizing a graph is useful because...

A. I forget what order normalizing is...
B. it highlights which peaks are integer and non-integer multiples of running speed C. it is confusing to relate the frequency in Hz or CPM to forcing frequencies

[3] True or false: Bearing forcing frequency calculations are 100% accurate.

A. True B. False

[4] A defect on a ball or roller will often cause which pattern in a spectrum?

A. High 1x
B. Cage rate vibration
C. Non synchronous peak with cage rate sidebands D. Non synchronous peak with 1x sidebands

[5] If we knew that BPO was 3.2X and BPI was 4.8X, how many balls are there?

A. There must be 8 balls (3.2 + 4.8 = 8) B. There must be 10 balls (2 + 8 = 10) C. There must be 7 balls (3 + 4 = 7)

[6] If you detected changes in vibration from a bearing at ultrasonic frequencies (and you don't see anything in other parts of the spectrum)...

A. you should change the bearings at your next opportunity
B. you should keep dogs away from the machine - it may hurt their ears C. you should continue monitoring for additional signs of wear

[7] If the inner race is spinning, which fault is described by these peaks in a spectrum: 3.2x, 4.2x, 5.2x, 8.4x, 12.6x

A. Outer race B. Ball fault C.

Inner race
D. Cage
fault

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[8] You should first consider replacing the bearings when...

A. you first detect an ultrasonic frequency

B. when you see an increase in amplitude at the bearing forcing frequencies

C. when you see strong harmonics and sidebands of the bearing forcing frequencies

D. when the bearing is glowing red and the screaming can be heard three buildings away

DIAGNOSING ELECTRIC MOTORS

[1] An eccentric stator (with a stationary differential air gap) will produce...

A. a high 1X peak at the motor running speed B. increased amplitude at twice line frequency C. harmonics of 1X with pole-pass sidebands

[2] An eccentric rotor (with a rotating differential air gap) will produce...

A. a high 1X peak at the motor running speed

B. a peak at the rotor bar frequency with twice line-frequency sidebands

C. increased amplitude at 1X vibration and twice line frequency, with pole-pass sidebands D. harmonics of 1X with pole-pass sidebands

[3] A motor (not on a VFD) turns at 1740 RPM. The pole-pass frequency is...

A. 60 RPM B. 24 Hz C. 29 Hz

D. 240 RPM

[4] A cracked rotor bar will produce...

A. a high 1X peak at the motor running speed

B. a peak at the rotor bar frequency with twice line-frequency sidebands C. increased amplitude at twice line frequency, with pole-pass sidebands D. harmonics of 1X with pole-pass sidebands around each harmonic

[5] The 'beating' phenomenon can indicate...

A. loose rotor bars

B. an eccentric slip ring

C. a bent or warped rotor D. an eccentric stator

[6] Loose rotor bars will produce...

A. a high 1X peak at the motor running speed

B. a peak at the rotor bar frequency with twice line-

frequency sidebands C. increased amplitude at twice line frequency, with pole-pass sidebands D. harmonics of 1X with pole-pass sidebands

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[7] What is the 'rotor bar frequency'?

A. The number of rotor bars times the slip frequency B. The slip frequency times the synchronous frequency C. The number of rotor bars times the running speed

D. The number of rotor bars times the synchronous speed

GEARBOX ANALYSIS

[1] The input gear of a single reduction gearbox has 32 teeth. Which of these patterns would you expect to see in the spectrum?

A. A peak at 32x only

B. Peaks at 8x, 16x, 24x and 32x C. Peaks at 31x, 32x, 33x

D. None of the above

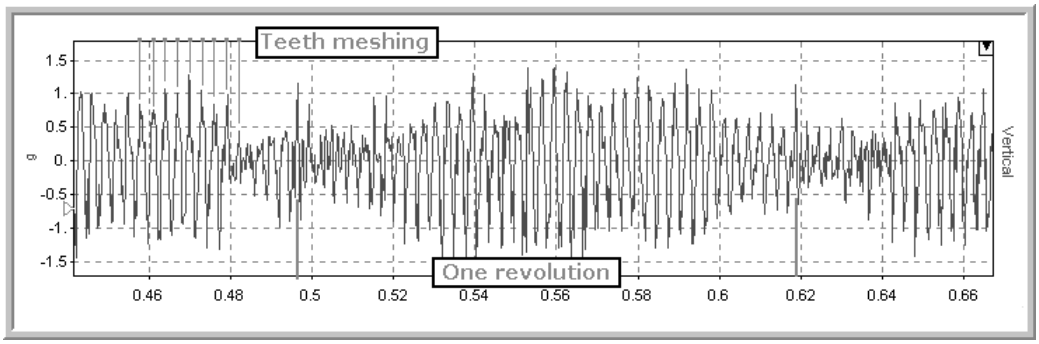
[2] Why is time waveform analysis useful in analyzing vibration from gearboxes?

A. You can easily identify the shaft speed from the time waveform B. You can see the pattern of wear on the teeth

C. You can detect damage to individual teeth

D. Time waveform analysis is good for all rotating components so it must be good for gearboxes

[3] What effect is present in the time waveform from this gearbox?



A. Looseness

B. Beating

C. Random vibration

D. Amplitude modulation

[4] What is the best tool for detecting cracked or broken gear teeth?

A. Motor current analysis
B. Perform thermographic analysis on the lubricant C. A wrench and a large hammer
D. Time waveform analysis

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BELTS

[1] The 'belt rate' forcing frequency is...

A. lower than the machine RPM B. higher than the machine RPM C. the same as the output RPM

[2] If a sheave/pulley is eccentric, the vibration pattern will produce...

A. a strong 1X component in the radial directions B. a series of harmonics of the belt rate
C. a strong 1X component in the axial direction D. strong 1X, 2X, and 3X peaks

[3] If a belt is worn or loose, the vibration pattern will produce...

A. a strong 1X component in the radial directions B. a series of harmonics of the belt rate frequency C. a strong 1X component in the axial direction
D. strong 1X, 2X, and 3X peaks

[4] If two sheaves/pulleys are not aligned correctly, the vibration pattern will produce...

A. a strong 1X component in the radial directions B. a series of harmonics of the belt rate
C. a strong 1X component in the axial direction D. strong 1X, 2X, and 3X peaks

[5] If a belt resonance coincides with the sheave/pulley RPM, the vibration pattern will produce...

A. a strong 1X component in the radial directions B. a series of harmonics of the belt rate
C. a strong 1X component in the axial direction D. strong 1X, 2X, and 3X peaks

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MAINTENANCE PRACTICES

[1] In a general sense, a plant that wishes to remain competitive will try to move from a _____ mode to a _____ mode of operation.

A. predictive / preventive B. reactive / proactive
C. run to failure / preventive D. proactive / predictive

[2] Proactive maintenance...

A. involves overhauling machines on a time basis.
B. involves removing the root causes of machine failure C. negates the need for condition monitoring.
D. is something that sounds great, but nobody actually does it.

[3] Condition monitoring is the same as predictive maintenance

E. True F. False

[4] All machines should be a part of a condition monitoring program.

A. True B. False

[5] When we simply react to machine failures, we are practicing...

A. Breakdown maintenance B. Preventive maintenance
C. Predictive maintenance

[6] Preventive maintenance often results in unnecessary overhauls.

A. True B. False

[7] Which maintenance philosophy can actually reduce plant reliability compared with doing nothing?

A. Root cause failure analysis B. Predictive maintenance
C. Preventive

maintenance D.
Proactive maintenance

[8] Which maintenance philosophy is also known as condition based maintenance?

A. Breakdown
maintenance B.
Predictive maintenance
C. Preventive
maintenance D.
Proactive maintenance

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[9] Which maintenance philosophy would result in lower spare parts cost?

A. Breakdown maintenance B. Predictive maintenance C. Preventive maintenance

[10] Why do we perform condition monitoring and predictive maintenance?

A. To reduce the production and maintenance costs.
B. So that we understand the current health of our machinery. C. Because visiting the machine reveals key information.
D. All of the above

[11] What is 'secondary damage'?

A. The damage done to a machine when failure occurs. B. The downtime to the machine.
C. The reduction of product quality due to high vibration. D.

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